Additional Records of Folliculinids (Protozoa) in Hawaii[1]

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THUS FAR, only three species of folliculinids have been recorded for Hawaii: Andrews (1944) assigned folliculinids from Kaena Point to *Parafolliculina annulata* [reassigned by Hadzi (1951) to *Halofolliculina annulata* (Andrews)]; and Matthews (1953) assigned folliculinids from Waimanalo Creek to *Metafolliculina andrewsi* Hadzi and those from the Hawaii Marine Laboratory to *Lagotia simplex* Dons.

This paper records two additional species taken on glass-plate panels (vid. Moebius, 1887). Each panel (Fig. 1) resembled a large open slide box and contained six 8 cm × 10 cm unetched glass plates. These panels, with floats and anchors adjusted, were placed in the dock lagoon, Hawaii Marine Laboratory, where they floated freely approximately a meter above the sand and coral bottom.

The first plate was removed and examined May 16, having been submerged 1 week; the second plate was examined May 23, having been submerged 2 weeks, and so on, until all plates had been removed. The cycle was then repeated.

Although pelogloea formation (Fox et al., 1952: 30) and sequential fouling were beyond the scope of this study, both were noted. Whereas some sedentary polychaetes and folliculinids attached to the plates' upper surface, most fouling organisms adhered to the under surface. Noteworthy, too, is the fact that, although *Metafolliculina andrewsi* was present on all plates, *Lagotia simplex* and *Halofolliculina annulata* were present on none.

During May, June, and July, attached, fully extended folliculinids were abundant, and from this material all measurements were made. Of these, lorica (test) measurements were usually easy; body measurements rarely so. This was primarily because of body contractility which, while it seldom affected the size and shape of the nonmoniliform nucleus, often affected the size, shape, and apparent number of moniliform nuclear conglomerates. However, the clarity and uniformity of other characters made identification of the following two species fairly certain:

Parafolliculina violaceae (Giard) 1888, Fragments biologique XIII. Sur les genres Folliculina et Pebrilla. Bulletin Scientifique de la France et de la Belgique, 3. ser., 1: 310–317.

These beautiful folliculinids (Fig. 2) were observed on all plates from May to July. Rarely were they distributed over the entire plate surface but, rather, were limited to small, closely compact areas, sometimes near the plate's edge but just as often near its center. In contrast to only nine specimens taken at Woods Hole by Andrews (1942: 94), each compact area often contained from 25 to 50 fully extended folliculinids. Thus, during the course of this brief study, several hundred specimens were observed.

Although the genus (Dons, 1912) is characterized by the presence of unique valves (Fig. 2*c*) which separate sac (*d*) from neck (*b*), these are not the structures which first call one's attention to this unusual folliculinid. Whereas a typical folliculinid (Fig. 3) with horizontal sac (*c*), blue-green body (*b*), and upright neck (*a*), resembles a delicate Grecian lamp with spiral chimney, *P. violaceae* (Fig. 2) with perpendicular sac (*d*), reddish-blue body (*e*) and valves (*c*) resembles a minute, upright wine bottle with portions of broken cork pushed down into the neck.

No reclining lorica with collectoderm (*h*) along the side of the sac was ever observed (Hadzi, 1951: 189); and although Andrews (1942: 94) states that the shape of the lower end of the sac varies considerably, the lower end of the sac of *P. violaceae* from Hawaii was consistently rounded (Fig. 2*g*).

Pertinent loricae measurement averages in microns are listed in Table 1 for *P. violaceae*

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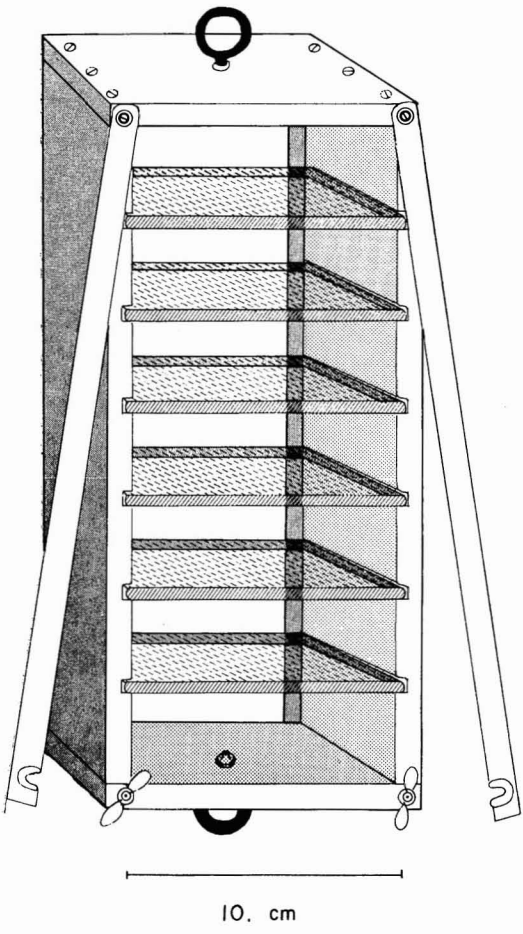


FIG. 1. Diagram of glass-plate panel showing float and anchor rings, inserted glass plates, and locking bars.

from British Columbia (Andrews, 1948: 63), Woods Hole (Andrews, 1942: 95), and from Hawaii.

Since loricae measurement averages for *P. violaceae* from British Columbia are based on extremes, with no knowledge of the actual number of individuals measured, these data cannot be adequately compared. However, measurements of the Hawaiian specimens usually fall well within those recorded elsewhere for this species.

Metafolliculina nordgardi Dons, 1924, Det. kgl. Norske Vidsk. Selskabs Shrifter. (1): 1–18.

These bizarre folliculinids (Figs. 4, 5, 6) were observed on plates May 16. Their numbers increased during June, decreased during July, and disappeared completely during August. Again, rarely were they evenly distributed over the plates' surface, but, rather, were limited to compact areas near the edges or, as frequently, near the center. The following lengths in microns are of 10 loricae taken at random: 1328, 1245, 1145, 1826, 1377, 1726, 1494, 1384, 1610, and 1261. Both Dons' (1924) specimens, collected on the Norwegian coast, and Hult's specimens (after Silén, 1947: 60), collected on the Swedish coast, were considerably smaller, ranging from 320–1130 μ.

Unlike other species of *Metafolliculina* which often attain lorica lengths of 500 μ or more and which have reduced but horizontal sacs (e.g., *M. perducta* Dons, 1934; *M. longicollis* Hadzi, 1938; *M. elongata* Das, 1949) (vid. Andrews, 1952: fig. B, and Fig. 3*a, c* of the present paper), *M. nordgardi* lacks a sac which can be

TABLE 1

MEASUREMENTS	BRITISH COLUMBIA (NO. NOT KNOWN)	WOODS HOLE (9 SPECIMENS)	HAWAII (25 SPECIMENS)
Total length	280	246	215
Sac length	196	159	149
Tube length	84	87	66
Mouth and collar width	*	40	66
Neck width	44	33	42
Vestibule width	50	49	58
Sac width	105†	62	58
Greatest sac depth	55	57	50
Least sac depth	30	28	36
Diameter of nucleus	*	22	25

* No measurements given.
† Obviously a mistake. Compare Andrews, 1948: figs. 1, 2.

differentiated either by shape, size, or position from the rest of the lorica. Hadzi (1951: 28) states, "One might say the abdominal part goes up into the throat."

Metafolliculina nordgardi in Hawaii agrees with its European counterpart in that both primary loricae (Fig. 4*b*) and primary and secondary loricae (Fig. 5 *de, bc,* and *cd*) are cylindrical (actually attenuated cones) but differ in that spiral thickenings are absent. According to Dons (1924), primary loricae (Figs. 4, 6) are the result of newly settled populations, whereas secondary loricae (Fig. 5) are the result of old populations. However, in Hawaii, primary lorica lengths of "newly settled" populations often exceeded the combined lengths of primary and secondary loricae of "old populations." For example, specimens 1 (1328 μ), 2 (1245 μ), 3 (1145 μ), 5 (1377 μ), 8 (1384 μ), and 10 (1261 μ) each possessed only a primary lorica.

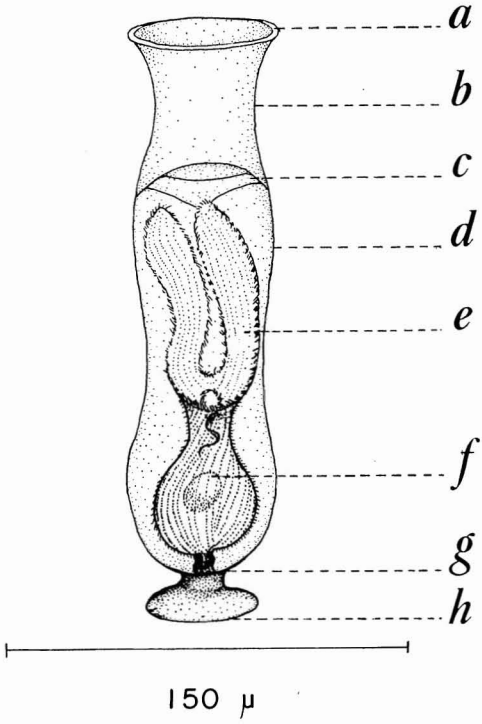


FIG. 2. Full-face view of partially contracted *P. violaceae* showing: *a,* lip; *b,* neck; *c,* dorsal valve; *d,* perpendicular sac; *e,* peristomal lobe of reddish-blue body; *f,* nonmoniliform nucleus; *g,* rounded, proximal portion of sac; *h,* collectoderm.

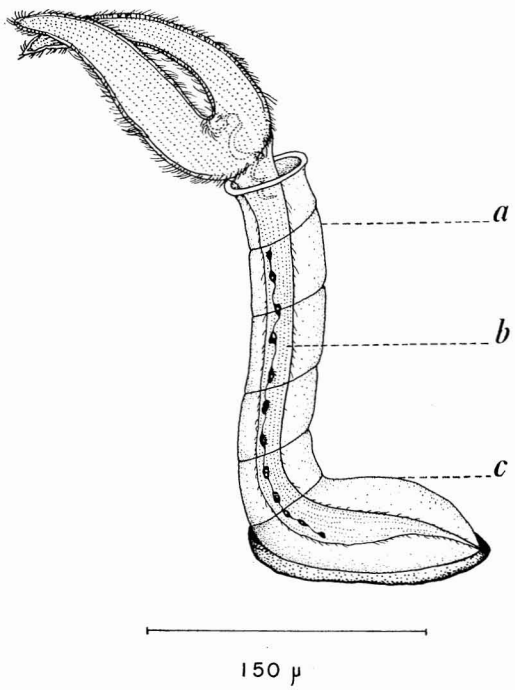


FIG. 3. Typical folliculinid as viewed from the left side showing: *a,* upright neck with spiral thickenings; *b,* extended, blue-green body with left and right peristomal lobes; *c,* horizontal sac.

None had the slightest indication of a spiral thickening or region where primary lorica ended and secondary began. Yet in example 9 (1610 μ), which was composed of a primary lorica (697 μ) and two secondary loricae (415 μ and 498 μ respectively), the combined length of primary and first secondary (1112 μ) was less than any of the primaries given above.

Since on any one plate, lengths of certain primary loricae may be greater than the combined lengths of others with both primary and secondary loricae, and if the deposition rate for both is assumed to be the same, then some *M. nordgardi* with only primary loricae are older than others with both primary and secondary loricae; hence the notion that secondary loricae are adaptations of older colonies to compensate for the choking effect of a heightened fouling layer is placed in serious doubt.

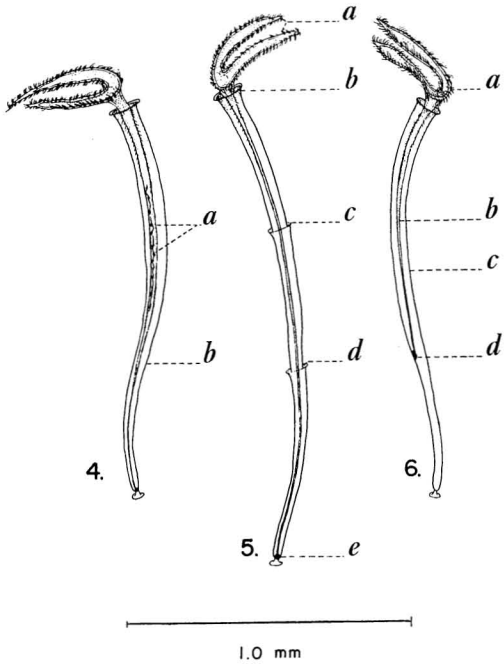
The delicate, blue-green body usually lay contracted in the small proximal portion of the lorica and, in this condition, neither peristomal

nor nuclear lobes could be discerned clearly. Although attempts to fix and stain these folliculinids in a relaxed condition failed, phase contrast microscopy and living material revealed moniliform nuclei (Fig. 4*a*) with up to 12 components.

In one specimen whose primary and two secondary loricae were 1826 μ long, the peristomal lobes of the relaxed body extended 253 μ above the test opening; yet the body still remained attached to the proximal end of the primary lorica by an extremely delicate, green filament. However, another specimen (Fig. 6), with a relaxed body 1128μ long, was able to extend its peristomal lobes (Fig. 6*a*) 249 μ above the opening of its 1244 μ-long primary lorica (*c*), apparently because its body (*b*) was attached (*d*) 365 μ above the proximal end of the lorica.

Much has been made of the relationship of these giant folliculinids to their substrate. Andrews (1952: 133) considered the extreme length of lorica an adaptation which raised the delicate body above the thick substrate and, at the same time, afforded protection from predators. Granted that the openings of certain loricae were located well above the fouling layer surface, the openings of very young loricae as well as those of smaller species were rarely so; yet, though these lacked protective height, they appeared not seriously affected.

Despite excellent, detailed studies of lorica formation by Andrews (1923) in *Folliculina producta,* Das (1947) in *Folliculinopsis producta,* Dewy (1939) in *Folliculina aculeata,* Fauré-Fremiet (1932) in *Folliculina simplex,* and Penard (1919) in *Folliculina boltoni,* the problem of whether secondary loricae (necks) are formed by (1) the original occupant of the primary lorica, (2) one of the daughter cells of the original occupant, (3) the dedifferentiated primary occupant, or (4) a new, free-swimming larva from some other lorica, still remains unsettled, yet might easily be solved by one well versed in the biological application of radioisotopes.



FIGS. 4–6. Fig. 4: Fully extended *M. nordgardi* with primary lorica; *a,* moniliform nucleus with 12 components. Fig. 5: Fully extended *M. nordgardi; a,* peristomal lobes; *bc* and *cd,* secondary loricae; *de,* primary lorica. Fig. 6: Fully extended *M. nordgardi* with primary lorica; *a,* peristomal lobes; *b,* body; *c,* primary lorica; *d,* attachment of body to side of lorica.

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